REMARKS

Claims 1-30 are pending in the Application. Claims 1, 19, and 30 have been amended to incorporate limitations from existing dependent claims. Claims 5, 11, 14, 27, and 29 have been canceled. No new matter has been added. The rejections of the claims are respectfully traversed in light of the amendments and following remarks, and reconsideration is requested.

Rejection Under 35 U.S.C. § 112

Claims 1-30 are rejected under 35 U.S.C. § 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention.

In particular, the Examiner writes in part:

> The specification described a film deposition process including: E/D ratios from 0.0 to about –0.05. The E/D = (UBUC-BUC)/UBUC
> Where UBUC is deposition rate with no bias; and BUC is deposition rate with bias.
> It is well known that, without bias, no etching component is present and with bias, there is an etching component. Therefore , the deposition rate of UBUC is **always** larger than with bias (BUC).
> The claimed invention, however, disclosed a negative E/D (-0.05).
> The negative E/D means BUC > UBUC.
> How can BUC be large[r] than UBUC while there is an etching component involve[d]?

Applicant discloses that "Table 1 . . . provides process parameter ranges . . . to form a silicon dioxide layer with a refractive index of 1.46." (Applicant's Specification as filed, page 9, lines 7-16). "UBUC is the deposition rate of the process with no wafer bias or clamping (unbiased, unclamped) . . . E/D ratios from about 0.0 to about -0.05 have been achieved for void-free gap filling, where the UBUC-deposited film refractive index ranges from about 1.5 to about 1.6". (Applicant's Specification, page 8, lines 10-11 and 19-22) (emphasis added). When the deposition rate of the process is measured with no wafer bias or clamping and no gas flow change (e.g., no increased O_2 levels), the UBUC-deposited film refractive index changes as compared to the BUC-deposited film refractive index. The deposition rate of UBUC is larger than the deposition rate of BUC for the same film having the same refractive

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index but is NOT always larger for <u>different films</u> having different refractive indices. Thus, under some conditions for low deposition rates and high aspect ratio gaps, the deposition rate with bias (BUC) may be larger than the deposition rate without bias (UBUC) because <u>the films being deposited in the two cases are of different composition</u> (more or less silicon-richness), and therefore the E/D ratio, as defined by Applicant, may be negative.

The Examiner states in his Response to Arguments that the aforementioned explanation of the negative E/D ratio is "conjecture" and that "Applicant fails to provide any support for his conclusion." A declaration from a qualified engineer corroborating the aforementioned explanation of the negative E/D ratio can be provided in a Supplemental Response to Office Action to support Applicant's statements if the Examiner so desires.

However, in order to put the Application into form for allowance, relevant Claims 14 and 29 have been canceled without prejudice. Accordingly, Applicant respectfully requests withdrawal of the rejection of the claims under 35 U.S.C. § 112, first paragraph.

Claims 14 and 29 are rejected under 35 U.S.C. § 112, second paragraph as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicant regards as the invention.

In particular, the Examiner writes in part:

> Claims 14 and 29 recites: wherein said film is deposited over said gaps at an etch-to-deposition ratio between about 0.0 and about –0.05.
>
> . . .
>
> Applicant further indicates that the negative signified different composition of the dielectric film, which means more or less silicon richness. (Remark, page 8).
>
> The claimed "-0.05" clearly contradict[s] the parent claims 1 and 19, which intended to form a dielectric film having a refractive index of about 1.46 (stoichiometry).
>
> Because at "-0.05" the dielectric layer is no longer stoichiometry thus, does not have a refractive index of about 1.46 or minimum necessary to form the dielectric.
>
> Therefore, claims 14 and 29 are not just fail to further limit the parent claims but also contradicting the scope of the parent claims, thus, indefinite.

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First, Applicant submits that parent Claim 1 is <u>not</u> limited to forming dielectric layers with a refractive index of about 1.46. Further, Applicant submits that the Examiner

misunderstands the E/D equation disclosed by Applicant. Although the E/D ratio may be negative, this does not mean that the film being deposited under BUC conditions is not at the selected refractive index. Applicant only gave as an example that the film deposited under UBUC conditions has a refractive index between about 1.5 and about 1.6 where the film deposited under BUC conditions is about 1.46. A negative E/D ratio does not "contradict" parent Claims 1 and 19 in any way but further limits the claims as additional claim elements.

However, in order to put the Application into form for allowance, relevant Claims 14 and 29 have been canceled without prejudice. Accordingly, Applicant respectfully requests withdrawal of the rejection of the claims under 35 U.S.C. § 112, second paragraph.

Rejection Under 35 U.S.C. § 102(b) or In the Alternative Under 35 U.S.C. § 103(a)

Claims 1-13, 15-28, and 30 are rejected under 35 U.S.C. § 102(b) as being anticipated by, or, in the alternative under 35 U.S.C. § 103(a) as being obvious over Papasouliotis et al. (U.S. Patent No. 6,030,881). Applicant respectfully traverses these rejections.

In rejecting the claims, the Examiner stated in part with respect to Claim 1:

> Papasouliotis teaches [a] method for filling a gap during integrated circuit fabrication as claimed including . . .
>
> performing an HDP-CVD process using the gas mixture to fill the gap with a dielectric (525), wherein the ratio of the oxygen containing component to the silicon-containing component is substantially the minimum necessary to form the dielectric. (See Figs. 5A-C).
>
> Note that, the ratio of the oxygen-containing component [to the silicon-containing component] in the gas mixture of Papasouliotis appears to be substantially the minimum necessary to form the dielectric. (emphasis added).

The Examiner stated in part with respect to Claim 19:

> Papasouliotis teaches [a] method for filling a gap during integrated circuit fabrication as claimed including . . .
>
> providing a minimum flow rate of oxygen-containing component to allow formation of a film having a refractive index of about 1.46; and
>
> filling the gap by depositing the film (525) over the gaps (510) by using the gas mixture for simultaneous high density

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> plasma chemical vapor deposition and sputter etching (HDP-CVD). (See Figs. 5A-C).
>
> Note that, the flow rate of oxygen-containing component of Papasouliotis appears to be a minimum to allow the formation of a dielectric film.
>
> Further, since the dielectric of Papasouliotis is SiO_2, thus, it meets the claimed refractive index limitation.

The Examiner stated in part with respect to Claim 30:

> Papasouliotis teaches [a] method for filling a gap during integrated circuit fabrication as claimed including . . .
>
> providing a gas mixture . . . having a ratio of oxygen-containing component to silicon-containing component [below about 1.3]; and
>
> <u>filling the gaps by using the gas mixture</u> for simultaneous high density plasma chemical vapor deposition and sputter etching (HDP-CVD). (See Figs. 5A-C).
>
> Note that, the ratio of the oxygen containing component to silicon-containing component in the gas mixture of Papasouliotis appears to include the claimed ratio.
>
> Further, within purview of one having ordinary skill in the art, it would have been obvious to determine the optimum ratio of the oxygen containing component to silicon-containing component in the gas mixture in the formation of the dielectric layer. See In re Aller, Lacey and Hall (10 USPQ 233-237) "It is not inventive to discover optimum or workable ranges by routine experimentation."

Applicant notes the following feature of his invention. Specifically, Applicant provides a method of filling high aspect ratio gaps without the void formations typical of the prior art using a <u>single gas mixture</u> with <u>a low ratio of the oxygen-containing component to the silicon-containing component</u> and/or <u>a low concentration of the oxygen-containing component</u> to form a film of a selected refractive index <u>without cusp formation</u>.

Papasouliotis stands in sharp contrast to such a process. Papasouliotis discloses deposition/etch <u>cycling</u> using <u>different gas mixtures</u> having different etch/dep ratios to fill the gap. In particular, Papasouliotis discloses "<u>multiple sequential deposition and etch steps</u> of different etch rate-to-deposition rate (etch/dep) ratios to fill high aspect ratio gaps" (Papasouliotis, col. 5, lines 19-21). The first step is a deposition step in which "<u>[c]usps 530 begin to form</u> at the corners of circuit elements 520 as SiO_2 layer 525 fills gap 510, as shown in FIG. 5A. Before <u>cusps 530</u> close the entry to gap 510, the deposition step is stopped." (Papasouliotis, col. 5, lines 58-61). The "deposition/etching <u>cycle</u> is repeated as many times

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as necessary until the resulting gap can be filled by a conventional HDP deposition step (FIG. 5A) without void formation, as shown in FIG. 5C." (Papasouliotis, col. 6, lines 9-12). Accordingly, Papasouliotis discloses a conventional HDP deposition step in which cusps are formed during deposition to fill a gap.

Applicants could find no mention in Papasouliotis of a ratio of the oxygen-containing component to the silicon-containing component as claimed or the refractive index of a dielectric.

In particular, Applicant could find no teaching or suggestion in Papasouliotis for performing an HDP CVD process using a single gas mixture to fill a gap with a dielectric at a selected refractive index, wherein the ratio of an oxygen-containing component to a silicon-containing component is substantially the minimum necessary to form the dielectric at the selected refractive index. Applicant could find no teaching or suggestion in Papasouliotis of the selecting of a flow rate of the silicon-containing component and the providing of a minimum flow rate of the oxygen-containing component to allow formation of a film having a refractive index of about 1.46. Applicant could find no teaching or suggestion in Papasouliotis of a single gas mixture having a ratio of an oxygen-containing component to a silicon-containing component below about 1.3 and using the single gas mixture for simultaneous high density plasma chemical vapor deposition and sputter etching to fill gaps.

Applicant further contends that it would not have been obvious to determine the optimum ratio of the oxygen-containing component to silicon-containing component in the gas mixture given that Papasouliotis does not mention the ratio, optimizing composition, or refractive index. Instead, Papasouliotis discusses deposition/etch cycling and "the need for optimizing the duration of deposition steps." (Papasouliotis, col.6, ll.66-67). Optimizing duration of deposition steps involved in cycling teaches away from an optimum composition of reactants for a single duration step, which may not be efficient or optimal in terms of step duration.

The Examiner further stated in part in his Response to Arguments:

> Applicant argues: Applicant could find no mention in Papasouliotis of a ratio of the oxygen-containing component to the silicon-containing component or the refractive index of a dielectric.

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> However . . . to find the flow ratio, one should look into the tables. For example, in table 1, the oxygen (claimed oxygen-containing components) flow rate 10-1000 sccm and the silane flow rate (silicon-containing components) 10-250 sccm. So, the flow ratio of oxygen-containing components to the silicon-containing components, as disclosed in tables 1 is 1:1 to 4:1. Note that, these [sic] ratio also includes below 1.3.

As noted above, Papasouliotis only discloses in its Tables 1-4 an extremely wide range of flow rates for oxygen and silane. However no mention is made of the ratio of these two components, optimizing composition, or even a refractive index. "A prior art suggestion for virtually endless experimentation is not a case of prima facie obviousness." In re Dow Chemical Co., 837 F.2d 469, 473, 5 U.S.PQ.2d 1529, 1532 (Fed. Cir. 1989). Furthermore, the Examiner should not use hindsight to determine what a reference discloses.

Accordingly, Applicant again submits that it would not have been obvious to determine the optimum ratio of the oxygen-containing component to silicon-containing component in the gas mixture given that Papasouliotis does not mention the ratio, optimizing composition, or refractive index. Instead, Papasouliotis discusses deposition/etch cycling and "the need for optimizing the duration of deposition steps." (Papasouliotis, col.6, ll.66-67). At the very least, Papasouliotis discloses cusp formation during the filling of gaps. Optimizing duration of deposition steps involved in cycling teaches away from an optimum composition of reactants for a single duration step, which may not be efficient or optimal in terms of step duration.

Even if Papasouliotis were to disclose a ratio of the oxygen flow rate to the silane flow rate as proposed by the Examiner, Papasouliotis does not disclose or suggest a gas mixture including an oxygen-containing component that is no more than 21% total concentration by volume of the gas mixture. As noted by the Examiner above, "in table 1, the oxygen (claimed oxygen-containing components) flow rate [is] 10-1000 sccm and the silane flow rate (silicon-containing components) [is] 10-250 sccm. So, the flow ratio of oxygen-containing components to the silicon-containing components, as disclosed in tables 1 is 1:1 to 4:1." Using such a linear extrapolation, Papasouliotis does not disclose or suggest a gas mixture including an "oxygen-containing component" that is "no more than 21% total concentration by volume of said gas mixture" as claimed in Claims 1, 19, and 30 (e.g., from the data in Table 1, the minimum concentration of oxygen is 10/(10+10+10) = 33%; from the data in

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Table 2, the minimum concentration of oxygen is 1000/(1000+1000+500+60) = 39%; from the data in Table 3, the minimum concentration of oxygen is 500/(500+600+170+250) = 33%; from the data in Table 4, the minimum concentration of oxygen is 700/(700+1000+300+30) = 34%).

Applicant discloses the critical nature of the reduced oxygen levels by stating, "Advantageously, the reduced flow rate or concentration of oxygen required for a selected flow rate or concentration of silane reduces the main sputtering component of the gas mixture, resulting in a reduction of sidewall redeposition, thereby helping to keep the gap open for filling." (Specification, page 7, line 31 – page 8, line 2).

Applicant also submits that dielectric materials have a refractive index, but Papasouliotis does not disclose or suggest a particular refractive index for its film. Although Papasouliotis may disclose SiO_2, this does not necessarily mean selection of a refractive index or even a particular refractive index since silicon dioxide films can have different refractive indices.

In contrast, amended Claim 1 recites a "method for filling a gap during integrated circuit fabrication, comprising . . . providing a gas mixture comprised of a silicon-containing component and an oxygen-containing component, wherein said <u>oxygen-containing component is no more than 21% total concentration by volume of said gas mixture</u> . . . and performing an HDP-CVD process <u>using the gas mixture to fill the gap</u> with a dielectric having a selected refractive index, wherein the ratio of the oxygen-containing component to the silicon-containing component is <u>below about 1.2</u> to form the dielectric having the selected refractive index and to <u>fill the gap without cusp formation</u>." Therefore, because Papasouliotis does not disclose or suggest all the limitations of Claim 1, Claim 1 is patentable over Papasouliotis.

Similarly, Claim 19 recites "providing a gas mixture comprised of silicon-containing and oxygen-containing components, wherein said <u>oxygen-containing component is no more than 21% total concentration by volume of said gas mixture</u> . . . and filling said gap <u>without cusp formation</u> by depositing said film over said gap using <u>said gas mixture</u> for simultaneous high density plasma chemical vapor deposition and sputter etching." Therefore, because Papasouliotis does not disclose or suggest all the limitations of Claim 19, Claim 19 is patentable over Papasouliotis.

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Similarly, Claim 30 recites "providing a gas mixture comprised of oxygen-containing and silicon-containing components, wherein said gas mixture has a ratio of said oxygen-containing component to said silicon-containing component below about 1.3, and further wherein said oxygen-containing component is no more than 21% total concentration by volume of said gas mixture; and filling said gap without cusp formation by using said gas mixture for simultaneous high density plasma chemical vapor deposition and sputter etching." Therefore, because Papasouliotis does not disclose or suggest all the limitations of Claim 30, Claim 30 is patentable over Papasouliotis.

Claims 2-4, 6-10, 12-13, and 15-18 are dependent on Claim 1 and contain additional limitations that further distinguish them from the cited reference. Therefore, Claims 2-4, 6-10, 12-13, and 15-18 are allowable for at least the same reasons provided above for Claim 1. Claims 20-26 and 28 are dependent on Claim 19 and contain additional limitations that further distinguish them from the cited reference. Therefore, Claims 20-26 and 28 are allowable for at least the same reasons provided above for Claim 19. For at least these reasons, Applicant respectfully requests allowance of Claims 1-4, 6-10, 12-13, 15-26, 28, and 30.

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Rejection Under 35 U.S.C. § 103(a)

Claims 14 and 29 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Papasouliotis. Claims 14 and 29 have been canceled, thus obviating the rejections. However, Applicant responds to the Examiner's comments regarding these rejections.

In rejecting Claims 14 and 29, the Examiner states that "since the deposition method of Papasouliotis includes depositing an oxide film in gap having an aspect ratio that is greater than the present invention, thus, the E/D ratio of Papasouliotis should at least include[ ] the claimed ratio to fill the gap without void."

Papasouliotis discloses that "the gap-fill capabilities of [prior art] processes or combinations of processes do not extend beyond aspect ratios of 1.3:1 at spacing 0.45 μm." (Papasouliotis, col.1, ll.48-53). Applicant discloses that "[i]n accordance with the present invention, gaps with aspect ratios over 4.0:1 and with widths of 0.1 micron have been filled without the formation of voids. Accordingly, Papasouliotis does <u>not</u> disclose filling a gap with a <u>single gas mixture/process step</u> where the gap has an aspect ratio that is greater than the present invention.

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CONCLUSION

For the above reasons, pending Claims 1-4, 6-10, 12-13, 15-26, 28, and 30 are believed to be in condition for allowance and allowance of the Application is hereby solicited. If the Examiner should have any questions or concerns, the Examiner is hereby requested to telephone Applicant's Attorney at (949) 752-7040.

I hereby certify that this correspondence is being deposited with the U.S. Postal Service as First Class Mail in an envelope addressed to: Commissioner for Patents, Alexandria, VA 22313-1450, on September 29, 2003.

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September 29, 2003

Respectfully submitted,

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